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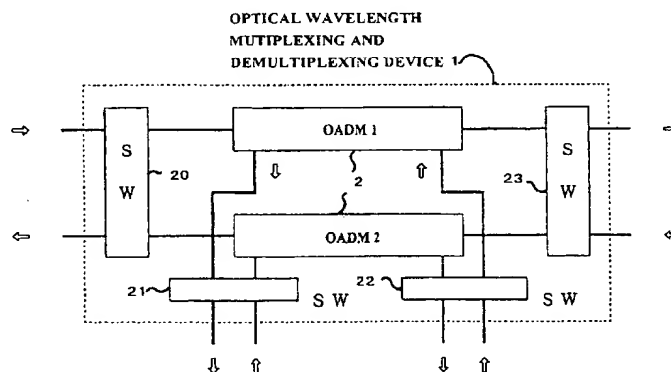
81925 München (DE)

(54) **An optical wavelength multiplexing and demultiplexing device and an optical transmission system using the same**

(57) An optical wavelength multiplexing and demultiplexing device may transmit an optical signal equivalent to a lost optical signal on a normal section in WDM network. The optical wavelength multiplexing and demultiplexing device includes an optical add-drop multiplexing circuit having a plurality of pairs of input and output ports and a plurality of path switches, each con-

nected to a corresponding pair of the plurality of pairs of input and output ports for breaking off an optical signal inputted to an input port of the corresponding pair, and switching a path of an optical signal output from an output port of the corresponding pair to the input port of the corresponding pair.

FIG. 2



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## Description

### BACKGROUND OF THE INVENTION

#### Field of the Invention

The present invention relates to an optical wavelength multiplexing and demultiplexing device used in a wavelength division multiplexing (WDM) optical communication network.

#### Description of the Related Art

An optical communication network employing a wavelength division multiplexing (WDM) technology has been extensively researched and developed in recent years.

Fig. 8 shows a schematic diagram of an example of an optical communication system, i.e., WDM network system, in which a plurality of optical wavelength multiplexing and demultiplexing devices are connected in series. One or more pairs of optical fibers OPF are provided for upward and downward communication lines as transmission paths.

The network system includes a plurality of optical amplifying repeaters REP in order to compensate losses in the optical fibers OPF. An optical amplifying repeater has two or more optical amplifiers OAMP for downward and upward lines.

Terminal offices A to D transmit a plurality of wavelength division multiplexed optical signals, i.e., WDM signals, each of which has a different wavelength, to one of the optical fibers. The optical wavelength multiplexing and demultiplexing device 1 distributes the WDM signals to transmission paths per a wavelength to transmit them to reception terminal offices A to D, which select wavelengths of the WDM signals and receive signals corresponding to the selected wavelengths.

The optical wavelength multiplexing and demultiplexing device 1 employed in the WDM network as shown in Fig. 8 is formed by combining optical add-drop multiplexers (OADM) 2 having a basic structure shown in Fig. 9.

The optical add-drop multiplexer 2 demultiplexes optical signals having some wavelengths ( $\lambda_{d1}$ ,  $\lambda_{d2}$  ...  $\lambda_n$ ) selected from the WDM signals, in which a plurality of wavelengths  $\lambda_{d1}$ ,  $\lambda_{d2}$  ...  $\lambda_n$  propagating in the transmission fiber of a main group are multiplexed, to branch to a transmission fiber of a branch group, which is, for example, transmission fiber 10, directed to the terminal office B. Then, the multiplexer 2 multiplexes the remaining optical signals with optical signals inputted from the transmission fiber of an insertion group, for example, a transmission fiber 11 transmitted from the terminal office B to the optical wavelength multiplexing and demultiplexing device 1, in order to output to the transmission fiber of the main group.

It is normal to select the same wavelength of the

optical signal to be demultiplexed as that of the optical signal to be inserted. The optical add-drop multiplexer 2 having the above-described characteristic can be produced by employing a wavelength multiplexing and demultiplexing element, such as a dielectric multilayer filter, a WDM coupler, a fiber grating, an AWG or the like. Accordingly, wavelength multiplexing and demultiplexing elements having various structures have already been proposed, in the first literature, titled as "An Experiment on Optical Add-Drop Multiplexer Using Fiber Grating and Its Limiting Factor" described in pp. 747 of a preliminary documentation of The institute of electronics, information and communication engineers, 1996, and second literature, titled as "Transmission Characteristics of Arrayed Waveguide N×N Wavelength Multiplexer described" in Journal of Light-wave technology vol. 13 No. 3 March, 1995

As described above, it is required to use at least one pair of optical fibers for upward and downward lines in an actual WDM optical communication system. Accordingly, the optical wavelength multiplexing and demultiplexing device 1 is formed with the use of, at least, two or more optical add-drop multiplexers 2 shown in Fig. 9.

Fig. 10 shows a supposed structural example of the optical wavelength multiplexing and demultiplexing device 1 employing the optical add-drop multiplexers 2. As shown in Fig. 10, the optical wavelength multiplexing and demultiplexing device 1 includes a pair of the optical add-drop multiplexers 2 for upward and downward directions. Then, each of the pair of the optical add-drop multiplexers 2 is connected to an optical fiber 11 for demultiplexing and optical fiber 10 for insertion and multiplexing.

In the WDM optical communication network employing the optical wavelength multiplexing and demultiplexing device 1 shown in Fig. 10, a level schedule of optical signals in a normal section is changed because of some losses of optical signals, which have passed through the normal section on breaking the transmission fiber in a certain section off.

Fig. 11 is a schematic diagram of an example of a simple WDM network to overcome the shortage of the supposed system. In the network of Fig. 11, sections D, E, and F exist between terminal offices A, B, and C and the optical wavelength multiplexing and demultiplexing device 1, respectively. Optical repeaters REP required for keeping a predetermined signal level are provided in each of sections D, E and F.

Further, it is assumed that the optical wavelength multiplexing and demultiplexing device 1 employs a structure as shown in Fig. 10. It is also assumed that each wavelength of signals shown in a following chart 1 is allocated to communicate with each terminal office.

## (CHART 1)

---

 TERMINAL OFFICE A  $\Rightarrow$  B  $\lambda$  2
 

---



---

 TERMINAL OFFICE B  $\Rightarrow$  A  $\lambda$  2
 

---



---

 TERMINAL OFFICE B  $\Rightarrow$  C  $\lambda$  3
 

---



---

 TERMINAL OFFICE C  $\Rightarrow$  B  $\lambda$  3
 

---



---

 TERMINAL OFFICE C  $\Rightarrow$  A  $\lambda$  1
 

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 TERMINAL OFFICE A  $\Rightarrow$  C  $\lambda$  1
 

---

Accordingly, an optical signal having a wavelength shown in Fig. 12 is propagated on each transmission path. Further, in Fig. 12, a circle marked shows a signal optical fiber.

Here, a case where an optical fiber cable of the section D is broken off in the above-described system will be considered. In this case, communication paths between terminal offices A and B or terminal offices A and C are broken off. However, a communication path between terminal offices B and C is kept, because the sections E and F are normal.

Accordingly, even if the optical fiber cable is broken off in the section D, it is preferred to give no effect on communication between the terminal offices B and C in order to operate a network system. However, for example, two wavelengths of  $\lambda$  1 and  $\lambda$  3 are propagated into the transmission path of the section E on normal condition. On the contrary, if the cable is broken off in the section D, only one wavelength of  $\lambda$  3 is propagated to the transmission path of the section E.

In this way, if a transmission path in a certain section is broken off, a number of signals, which pass a transmission path in other normal section, is decreased.

On the other hand, an output control system has been used in the conventional optical amplifying repeaters, especially for a submarine optical communication system in order to make average optical power constant. Therefore, if a number of signals, which pass through the transmission path in a normal section, is decreased because of breaking the cable in a certain section off, a signal level schedule for one wavelength in the normal section is also changed at the end. Influence of non-linear effect of an optical fiber becomes strong according to the change of the signal level schedule, there has been a case where quality of transmission was deteriorated.

To overcome the above-described problem, it has been proposed to provide a function of controlling a gain of an optical amplifying repeater to be kept constant, so that there is no change of the signal level schedule, even if the number of wavelengths is changed.

However, there has been a problem that a structure of optical amplifying repeater becomes complex in order to obtain the function of controlling the gain of the opti-

cal amplifying repeater to be kept.

It is a key point that a signal level schedule in a normal section has been changed because some of optical signals passing in a normal section are fallen down by breaking the cable off in the certain section.

## SUMMARY OF THE INVENTION

Accordingly, it is an object of the present invention to provide an optical wavelength multiplexing and demultiplexing device, whereby an optical signal equivalent to the lost optical signal can be transmitted to overcome the shortage as discussed above in a WDM network.

It is another object of the present invention to provide an optical wavelength multiplexing and demultiplexing device including a path switching function in order to transmit optical signals equivalent to the lost optical signal in the WDM network.

Further, other objects of the present invention become clearly by the description for explaining embodiments according to the attached drawings.

## BRIEF DESCRIPTION OF THE DRAWINGS

Figs. 1A to 1B show a block diagram showing an applied example of an optical wavelength multiplexing and demultiplexing device and a WDM network using the device according to the present invention.

Fig. 2 is a structural diagram of the optical wavelength multiplexing and demultiplexing device 1 of the present invention to improve the function shown in Fig. 1.

Figs. 3A and 3B are schematic diagrams of optical switches 20 to 23, which are used as path switches.

Fig. 4 shows a first embodiment of the path switches 20 to 23 employed in the optical wavelength multiplexing and demultiplexing device 1.

Fig. 5 shows other structural example of the path switches 20 to 23 employed in the optical wavelength multiplexing and demultiplexing device 1.

Fig. 6 is a structural example of the other path switches 20 to 23.

Fig. 7 is an explanatory diagram of generating control signals in each embodiment.

Fig. 8 shows an example of an optical communication system, i.e., a WDM network system, which is produced as a network by the use of the optical wavelength multiplexing and demultiplexing device.

Fig. 9 is a diagram showing a general structure of the optical wavelength multiplexing and demultiplexing device 1 employed in the WDM network.

Fig. 10 shows a structural diagram of the supposed system of the optical wavelength multiplexing and demultiplexing device employing optical add-drop multiplexer 2.

Fig. 11 is a diagram for explaining a problem generated because of losses of some optical signals, which

pass through normal sections on breaking a transmission fiber in a certain section off.

Fig. 12 is an explanatory diagram of a wavelength of an optical signal propagated to each transmission path.

## DESCRIPTION OF THE PREFERRED EMBODIMENTS

Throughout the following descriptions, the same reference numerals are used to denote and identify corresponding or identical components.

Figs. 1A and 1B are block diagrams showing a structure of an optical wavelength multiplexing and demultiplexing device according to the present invention and a WDM network using the device. Fig. 1A shows a normal situation. Shown is a case where each wavelength of signals as shown in Fig. 12 is distributed to transmit an optical signal between the terminal offices A, B and C.

Fig. 1B shows a case where a cable is broken off in the section D. In this case, an optical wavelength multiplexing and demultiplexing device 1 according to the present invention breaks input and output paths in the section D, in which the optical cable is broken off. Further, the optical wavelength multiplexing and demultiplexing device 1 has a function for directly connecting input and output ports on the broken section side.

On a normal condition, optical signals having wavelengths of  $\lambda_1$  and  $\lambda_2$  are inserted to an input port of the section D. Then, optical signals having wavelengths of  $\lambda_1$  and  $\lambda_2$  are outputted from an output port. In this way, it is designed that WDM signals having the same signal wavelengths and the same number of wavelengths are passed through a pair of upward and downward lines of the optical fibers. Therefore, according to the present invention, the optical wavelength multiplexing and demultiplexing device 1 directly connects in correspondence to input and output ports having the same wavelength on breaking a cable off.

As shown in Fig. 1B, the WDM signals equivalent to that on normal condition are propagated to the normal section E. Therefore, the signal level schedule is not changed.

Fig. 2 is a structural example of the optical wavelength multiplexing and demultiplexing device 1 of the present invention to obtain the function as shown in Fig. 1. Optical switches 20 to 23 for switching a path are provided at each input and output section of the supposed optical wavelength multiplexing and demultiplexing illustrated in Fig. 10.

Figs. 3A and 3B show an explanatory diagram of the function of optical switches 20 to 23 used as path switches.

Fig. 3A illustrates a normal condition. In Fig. 3A, an optical signal is inputted to an input port I, and is outputted from an output port O as it is. On the contrary, Fig. 3B illustrates an abnormal condition. In Fig. 3B, an opti-

cal signal inputted to an input port I according to a certain condition, is broken off, and a path of the optical signal outputted from an output port O is switched in order to return to the input port I.

Fig. 4 shows a first embodiment of path switches 20 to 23 employed in the optical wavelength multiplexing and demultiplexing device 1. In Fig. 4, 2x2 optical matrix switch 201 is employed as a path switch.

The 2x2 optical matrix switch 201 has two input ports and two output ports. On a normal condition, the 2x2 optical matrix switch 201 has an input port ① connecting to a transmission path, in which an optical signal is inputted to the optical add-drop multiplexer 2, an output port ② connecting a transmission path, in which an optical signal is outputted from the optical add-drop multiplexer 2, an output port ③ connecting to an input port IP of the optical add-drop multiplexer 2, and an input port ④ connecting an output port OP of the optical add-drop multiplexer 2.

It becomes possible to turn the optical signal from the path of the output port ③ to the input port ④ via a broken line PO by switching with the use of a control signal to the 2x2 optical matrix switch 201.

In this case, the condition becomes the same as that of switching the paths as shown in Fig. 3B.

For example, a 2x2 magnetic optical switch (see the third literature titled as "DC-drift free Ti:LiNbO<sub>3</sub> Optical Switch with Low Radiation Loss", pp. 295 of the institute of electronics, information and communication engineers, 1996), a LiNbO<sub>3</sub> Mach-Zehnder type optical switch employing electro-optics effect (see the fourth literature titled as "2x2 Magnetic Optical Switch", pp. 259, of the institute of electronics, information and communication engineers, 1996), an optical switch employing a semiconductor amplifier (see the fifth literature, titled "High Speed and Low Crosstalk Switching Characteristics of 2x2 Gate Type Optical Switch", pp. 538 of the institute of electronics, information and communication engineers, 1996), or a mechanical optical switch can be used or as a 2x2 optical switch employed in the present invention.

Fig. 5 illustrate other structural example of path switches 20 to 23 employed in the optical wavelength multiplexing and demultiplexing device. The path switch shown in Fig. 5 is formed of a 2x1 optical switch 202 and a 1x2 optical switch 204.

The 2x1 optical switch 202 includes two input ports and two output ports. Either of two input ports is connected to one output port. The 1x2 optical switch 204 further includes one input port and two output ports. One output port is outputted either of the two output ports.

On a normal situation, each of the optical switches 202 and 204 is controlled by a control signal so as that the input port ① of the 2x1 optical switch 202 is connected to a transmission path, to which a signal is inputted to the optical wavelength multiplexing and demultiplexing device 1, the output port ② of the 1x2

optical switch 204 is connected to a transmission path, from which a signal is outputted, the output port ③ of the 2×1 optical switch 202 is connected to an input port of the optical wavelength multiplexing and demultiplexing device 1, and further, the input port ④ of the 1×2 optical switch 204 is connected to the output port of the optical wavelength multiplexing and demultiplexing device 1.

Additionally, the other output port of the 1×2 optical switch 204 and the other input port of the 2×1 optical switch 202 are connected via a signal level controller 203, such as an optical amplifier or an optical attenuator or the like.

Accordingly, it is possible to switch the 2×1 and 1×2 optical switches 202 and 204 to paths P0 and P1 illustrated with broken lines by a control signal in order to return an optical signal outputted from the output port of the optical wavelength multiplexing and demultiplexing device 1 from the input port ④ of the 1×2 optical switch 204 to the output port ③ of the 2×1 optical switch 202 via the level controller 203. This case will be also the same as that on the condition of switching the path shown in Fig. 3B. Further, in this embodiment, the optical signal is returned via the level controller 203. Therefore, it is easy to correspond the level with the normal level by the use of the controller 203.

For example, a magnetic optical switch, LiNbO<sub>3</sub>-Mach-Zehnder type switch employing electro-optics effect, an optical switch with the use of the semiconductor amplifier, the mechanical switch or the like can be used as the 2×1 and 1×2 optical switches 202 and 204.

Fig. 6 shows still other structural example of the path switches 20 to 23. In this example, two 2×2 optical switches 205 and 206 are included in the structure.

An input port ① of the 2×2 optical switch 205 and an output port ② of the 2×2 optical switch 206 are respectively connected to the transmission path, to which a signal is inputted to the optical wavelength multiplexing and demultiplexing device 1, and the transmission path, from which a signal is outputted. Further, an output port ③ of the 2×2 optical switch 205 and an input port ④ of the 2×2 optical switch 206 are respectively connected to the input port IP and the output port OP of the optical wavelength multiplexing and demultiplexing device 1.

Then, the other output port and the other input port of the 2×2 optical switch 206 are respectively connected to the other input port ⑤ and the other output port ⑥ of the 2×2 optical switch 205 via the level controllers 203 and 207.

With this structure, it is possible to switch a route of a broken line PO1 - the level controller 203 - a broken line PO2 to a route of a broken line P10 - the level controller 207 - a broken line P11.

In comparison with the structure shown in Fig. 5, it is different point that the path is switched to the signal inputted from the transmission path to transmit to a downward transmission path. It is possible to switch the

path to the above-described route of the broken line P10 - the level controller 207 - the broken line P11.

The route is required to check the condition of the system after the broken point of the transmission path is restored.

It is further possible to transmit optical power equivalent to the normal condition, even if the path is switched on abnormal condition or on checking the system, because the level controllers 203 and 207, such as an optical amplifier, an optical attenuator or the like, are provided between the two 2×2 optical switches 205 and 206.

Fig. 7 is an explanatory diagram of generation of a control signal in the above-described embodiment. In Fig. 7, reference numeral 200 is an optical switch for switching the path in each embodiment.

A signal, which is inputted to the optical wavelength multiplexing and demultiplexing device 1, is inputted to the path switches 20 to 23. Then, an optical coupler 210 demultiplexes a part of the signal inputted to the optical switch 200. After demultiplexing the signal, the demultiplexed signal is led to a photo diode (PD) 212 via an optical filter 211 to convert to an electrical signal. A controller 213 monitors the converted electrical signal.

The optical filter 211 arranged between the optical coupler 210 and the photo diode 212 keeps monitor sensitiveness well by separating the optical signal to be monitored from an optical signal having different wavelength or ASE noise. A wavelength selective element, such as a dielectric multilayer filter, a fiber grating, a bulk diffraction grating or the like can be used as an optical filter.

Subsequently, the controller 213 monitors and detects the size of the electrical signal, which is converted from the optical signal to determine the existence of the inputted optical signal transmitted from the transmission path. If there is no input signal, the controller 213 generates a control signal to activate the optical switch 200 in order to switch the path as explained above in each embodiment.

An operation principle of switching paths is different according to the type of the optical switch 200.

It is not restrictive to the structure shown in Fig. 7 to generate a control signal for switching the path in the optical wavelength multiplexing and demultiplexing device 1. For example, it is also possible to switch the path by converting an received optical signal modulated by a monitoring control signal to an electrical signal, demodulating the monitoring control signal from the electrical signal and activating the optical switch 200 according to the demodulated monitoring control signal.

Some kinds of methods for transmitting a monitoring control signal from a terminal office to a repeater have been already proposed for practical use in a submarine optical communication system. For example, a method for piling up and modulating a monitoring control signal to a data signal, i.e., a main signal, to be transmitted, or a method for modulating an amplitude of

the optical signal having a different wavelength from that of the main signal may be used for transmitting a monitoring control signal.

The optical wavelength multiplexing and demultiplexing device according to the present invention can be also applied to the case where the monitoring control signal is transmitted, even if either of the above-described methods is employed.

As described above in the embodiments, according to the present invention, even if a transmission path in a certain section is broken off in an optical signal transmission system, it becomes possible that a signal level schedule for passing the transmission path in a normal section is not changed, and the transmission quality caused by influence of non-linear effect of the optical fiber is not deteriorated.

The present invention may be embodied in other specific forms without departing from the spirit or essential characteristics thereof. The present embodiment is therefore to be considered in all respects as illustrative and not restrictive, the scope of the invention being indicated by the appended claims rather than by the foregoing description and all changes which come within the meaning and range of equivalency of the claims are therefore limited to be embraced therein.

## Claims

1. An optical wavelength multiplexing and demultiplexing device including:
  - an optical add-drop multiplexing circuit having a plurality of pairs of input and output ports; and
  - a plurality of path switches, each connected to a corresponding pair of the plurality of pairs of input and output ports for breaking off an optical signal inputted to an input port of the corresponding pair, and switching a path of an optical signal output from an output port of the corresponding pair to the input port of the corresponding pair.
2. The optical wavelength multiplexing and demultiplexing device according to claim 1,
  - wherein each of the plurality of path switches includes an optical matrix switch having two input ports and two output ports, one of the two output ports being connected to one of the two input ports, which is paired with the one of the two output ports by a control signal thereby that said path of an optical signal output from an output port of the corresponding pair.
3. The optical wavelength multiplexing and demultiplexing device according to claim 1,
  - wherein each of the plurality of path switches includes a first optical matrix switch having two

input and one output ports and a second optical matrix switch having one input and two output ports;

a first input port of the first optical matrix switch being connected to a transmission path, to which an optical signal is inputted,

a first output port of the second optical matrix switch being connected to a transmission path, from which an optical signal is outputted,

the output port of the first optical matrix switch being connected to an input port of the optical add-drop multiplexing circuit, and

the input port of the second optical matrix switch being connected to an output port of the optical add-drop multiplexing circuit, and

said first and second optical matrix switches are controlled by a control signal to connect the second output port of the second optical matrix switch to the second input port of the first optical matrix switch thereby that an optical transmission path is switched.

4. The optical wavelength multiplexing and demultiplexing device according to claim 3,

further comprising a controller provided between the second output port of the second optical matrix switch and the second input port of the first optical matrix switch.

5. The optical wavelength multiplexing and demultiplexing device according to claim 1,

wherein each of the plurality of path switches includes first and second optical matrix switches, each having two input ports and two output ports;

a first input port of the first optical matrix switch being connected to a transmission path, to which an optical signal is inputted,

a first output port of the second optical matrix switch being connected to a transmission path, from which an optical signal is outputted,

the input port of the optical add-drop being connected to the first output port of the first optical matrix switch, and

the output port of the optical add-drop being connected to the first input port of the second optical matrix switch, and

said first and second optical matrix switches are controlled by a control signal to connect the second output port of the second optical matrix switch to the second input port of the first switch, and connect the second output port of the first optical matrix switch to the second input port of the second optical matrix switch, thereby that an optical transmission path is switched.



6. The optical wavelength multiplexing and demultiplexing device according to claim 5,

further comprising controllers provided between the second output port of the second optical matrix switch and the second input port of the first matrix optical switch, and between the second output port of the first optical matrix switch and the second input port of the second optical matrix switch.

7. The optical wavelength multiplexing and demultiplexing device according to claim, further including:

an optical coupler provided in a transmission line, to which optical signals are inputted, for demultiplexing an optical signal inputted from the transmission line;

a photo diode for converting the optical signal demultiplexed by the optical coupler to an electrical signal;

a control circuit for detecting a size of the electrical signal converted by the photo diode, determining existence of an optical signal transmitted from the transmission line according to the size of the detected electrical signal, and generating the control signal, which activates switching of the path switches, when the existence of the input optical signal is not determined.

8. The optical wavelength multiplexing and demultiplexing device according to claim 1,

wherein the optical signal is modulated by a monitoring signal, and there are further comprised of,

an optical coupler provided in a transmission line, to which the optical signal is inputted, for demultiplexing an optical signal inputted from the transmission line;

a photo diode for converting the optical signal demultiplexed by the optical coupler to an electrical signal; and

a controller for demodulating the monitoring signal from the electrical signal converted by the photo diode, activating the optical switch according to the modulated monitoring signal to switch the transmission line.

9. The optical wavelength multiplexing and demultiplexing device according to claim 7,

further comprising an optical filter provided between the optical coupler and the photo diode for extracting a wavelength of an optical wavelength component from the optical signal demultiplexed.

10. An optical transmission system comprising:

first, second and third terminal offices; and an optical wavelength multiplexing and demultiplexing device connected via optical amplifiers to the first, second, and third terminal offices for demultiplexing a first specified wavelength of wavelength division multiplexed optical signals transmitted from the first terminal office to transmit to the second terminal office, for multiplexing optical signals having other wavelengths with an optical signal transmitted from the second terminal office to transmit to the third terminal office, and for demultiplexing a second specified wavelength of wavelength division multiplexed optical signals transmitted from the third terminal office to transmit to the second terminal office, for multiplexing optical signals having other wavelengths with an optical signal transmitted from the second terminal office to transmit to the third terminal office;

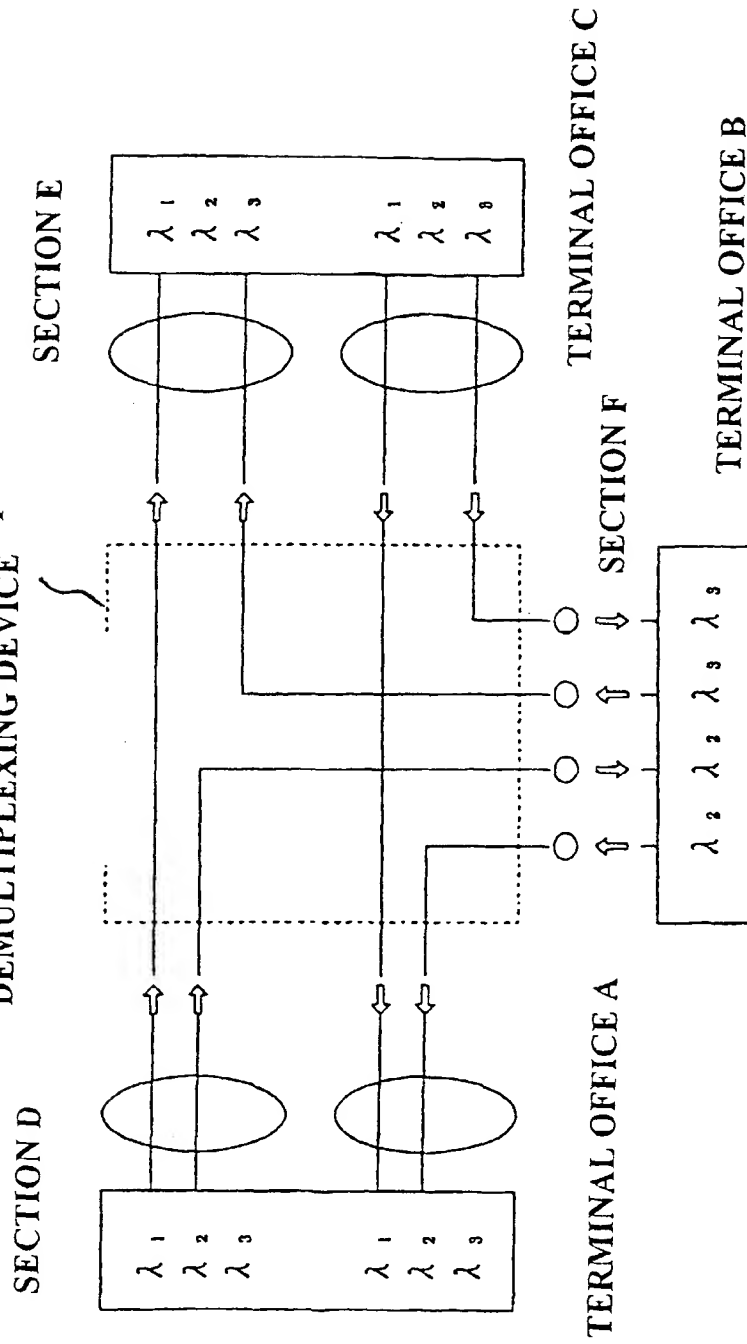
wherein optical signals transmitted from the second and third terminal offices to the first terminal office are returned to respectively to the second and third terminal offices, when fault is generated between the first terminal office and the optical wavelength multiplexing and demultiplexing device.

11. The optical transmission system according to claim 10;

wherein the optical signals transmitted from the second and third terminal offices to the first terminal office are returned to respectively to the second and third terminal offices by using optical signals from the first terminal office to wavelengths, which are assigned for transmitting the second and third terminal offices.

FIG. 1A

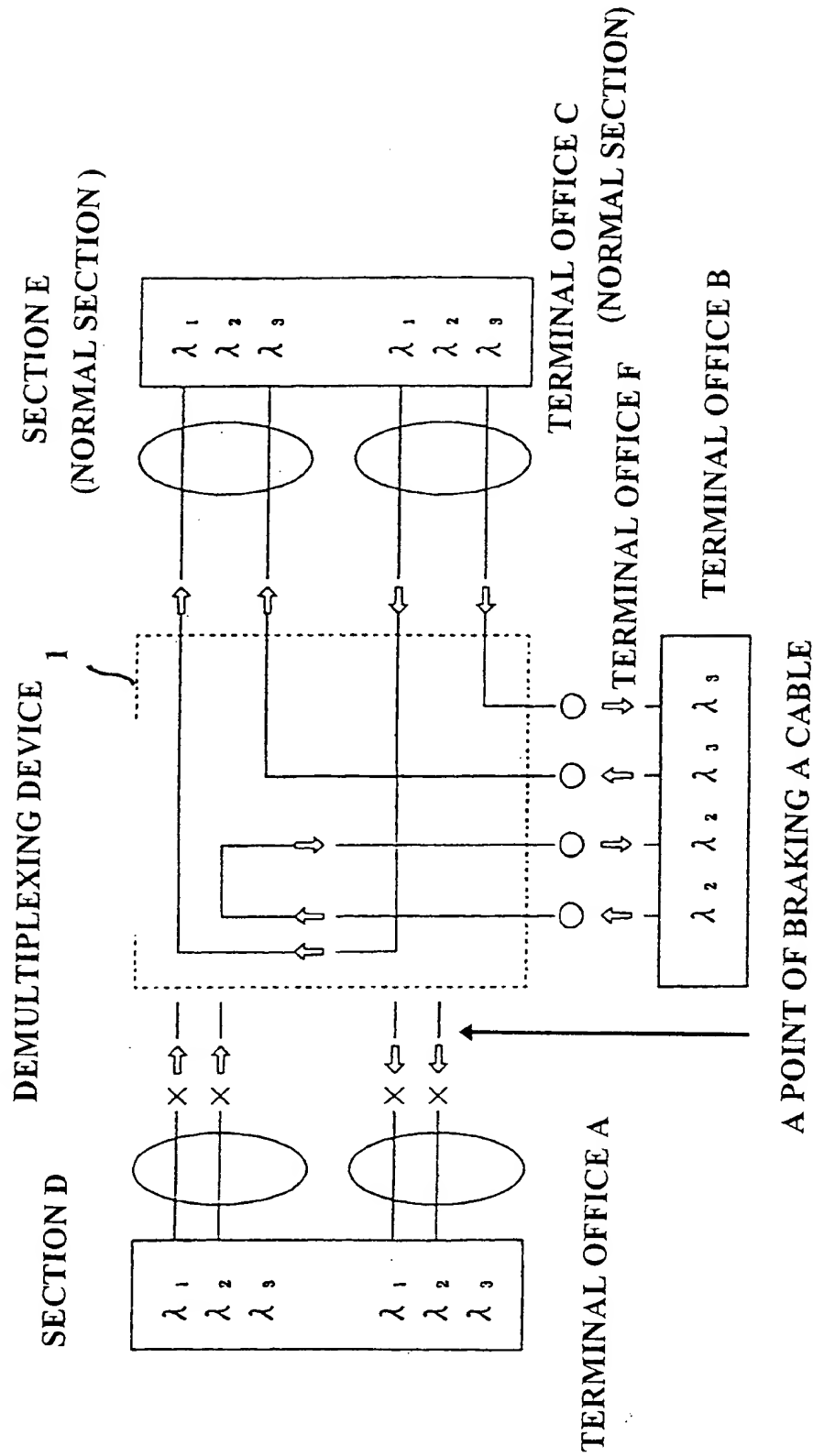
OPTICAL WAVELENGTH  
MULTIPLEXING AND  
DEMULTIPLEXING DEVICE 1



ON NORMAL CONDITION

FIG. 1B

OPTICAL WAVELENGTH  
MULTIPLEXING AND



ON BREAKING A CABLE OFF

FIG. 2

OPTICAL WAVELENGTH  
MULTIPLEXING AND  
DEMULTIPLEXING DEVICE 1

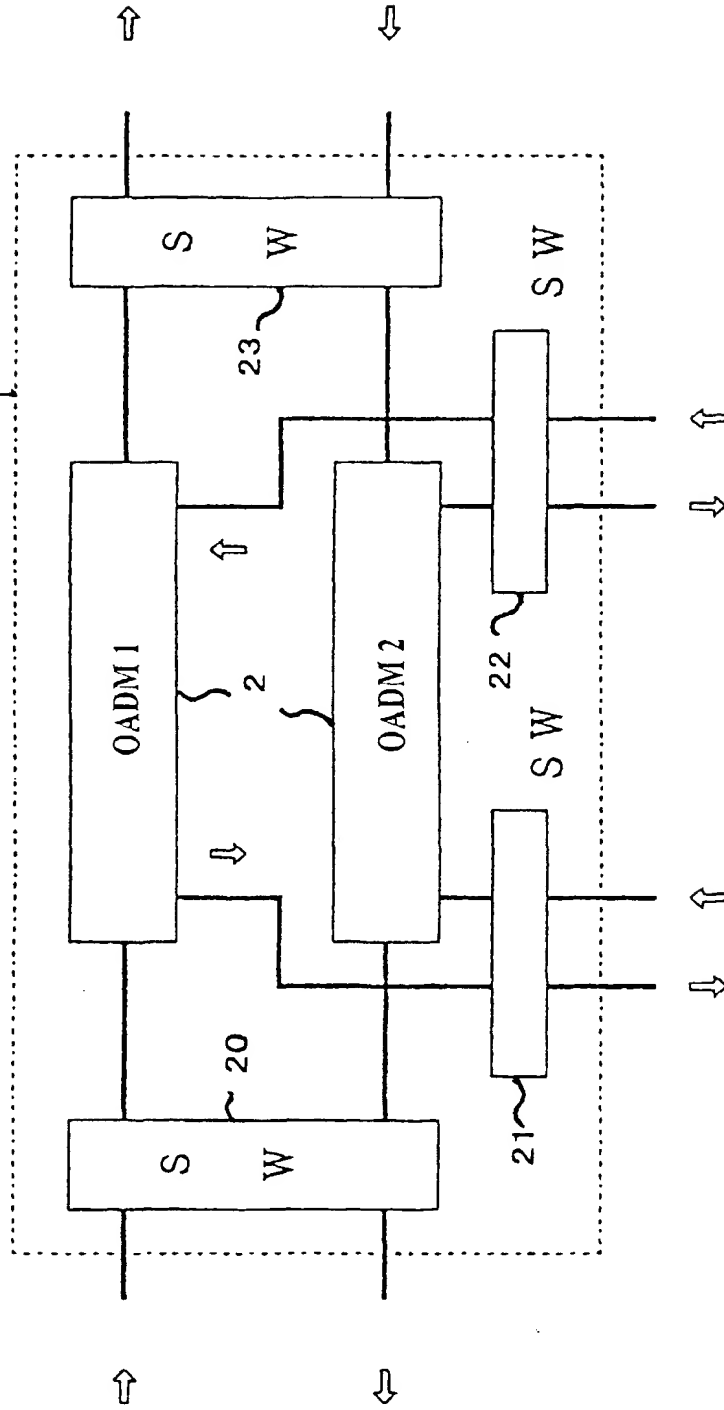


FIG.3B

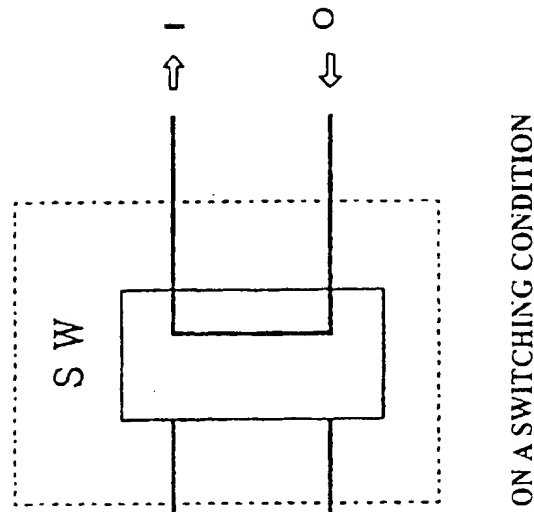


FIG. 3A

PATH SWITCH

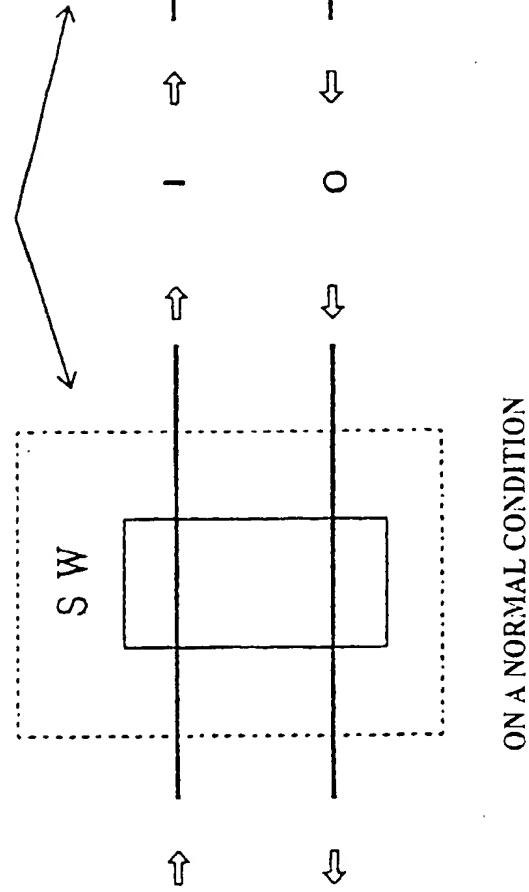


FIG. 4

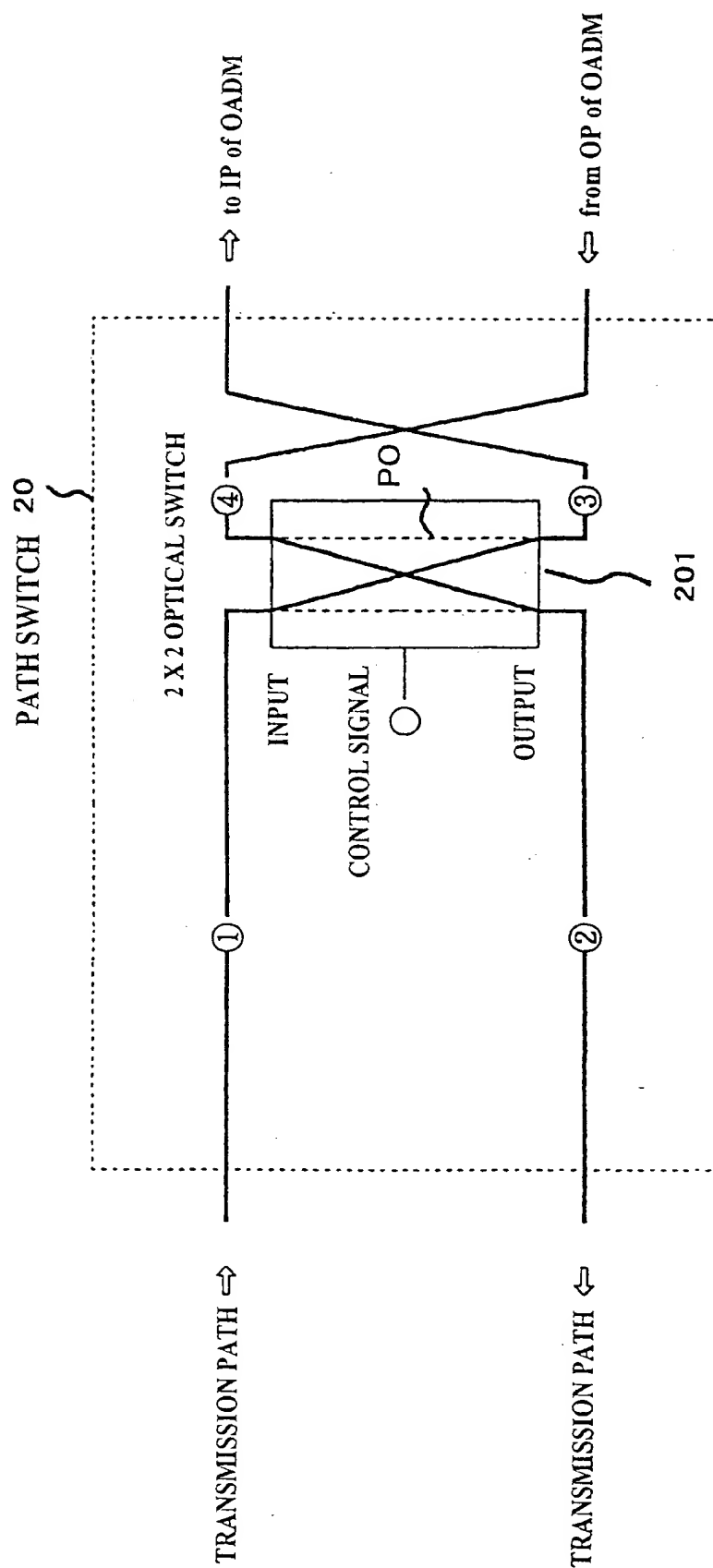


FIG. 5

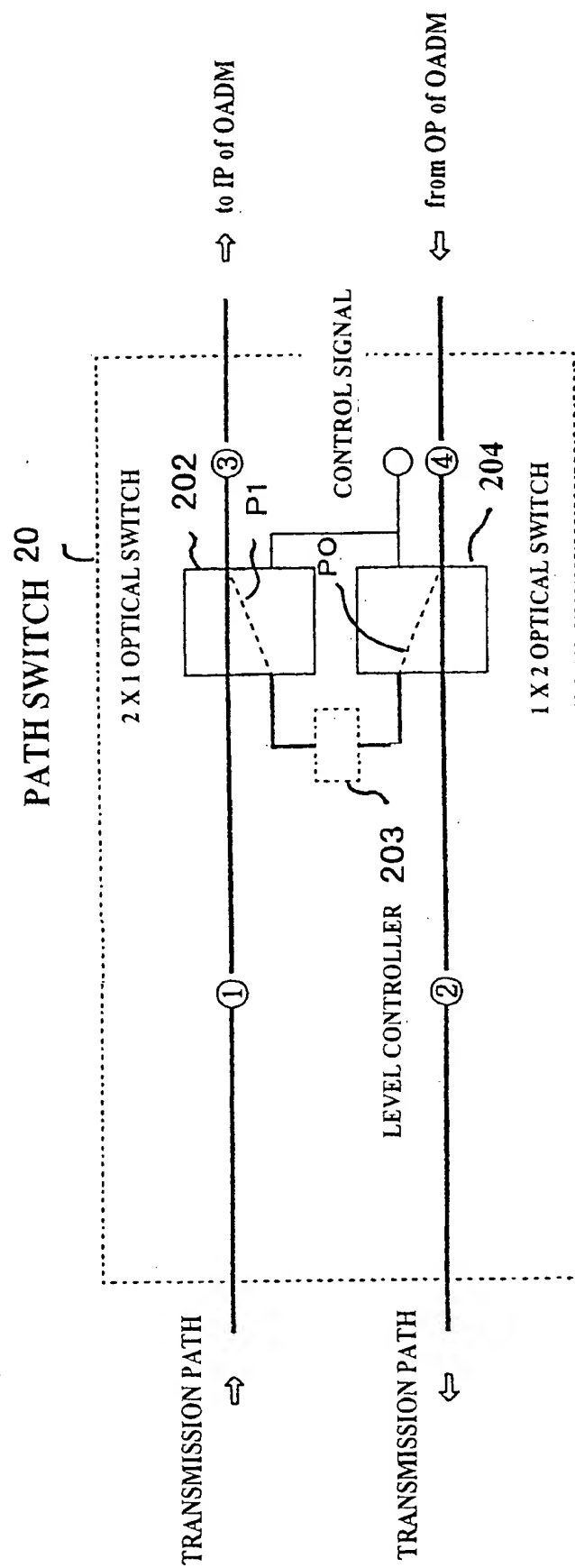


FIG. 6

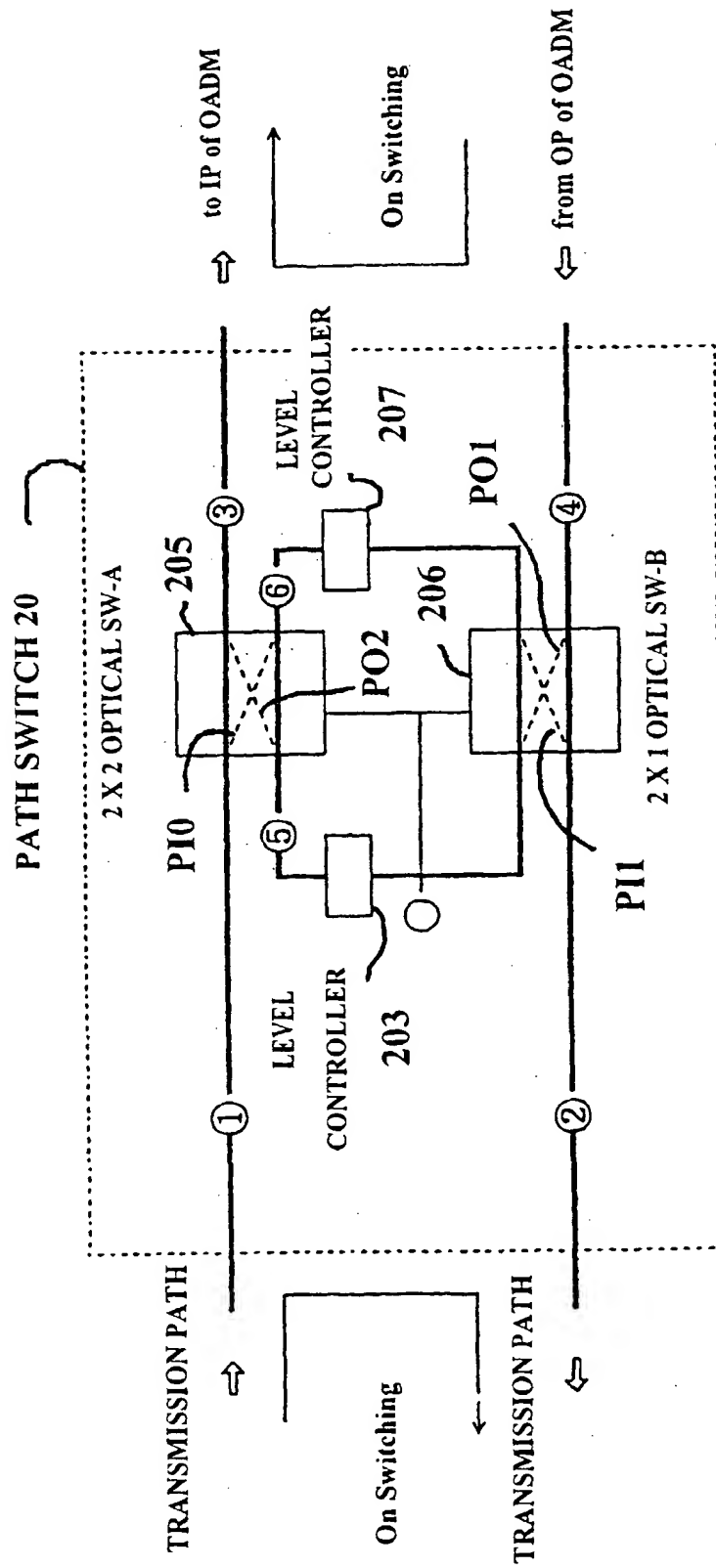




FIG. 7

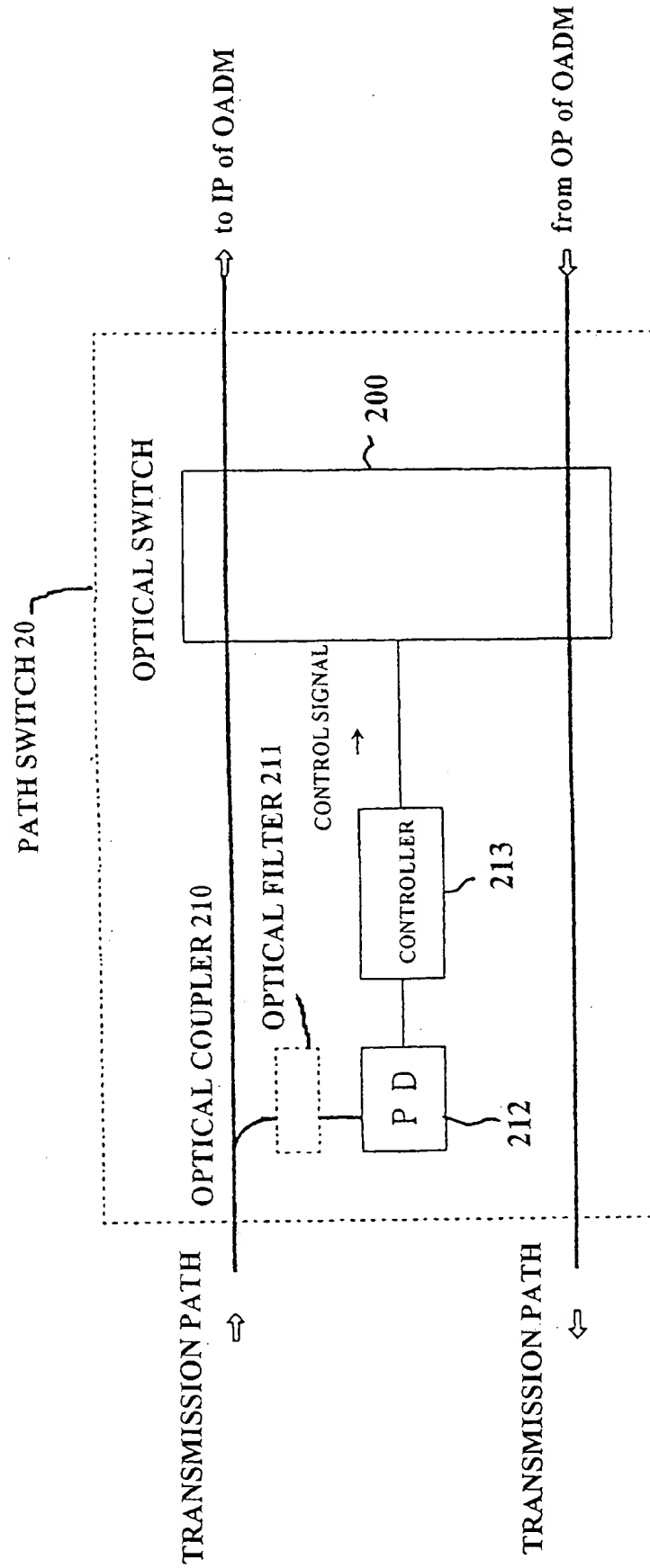


FIG. 8

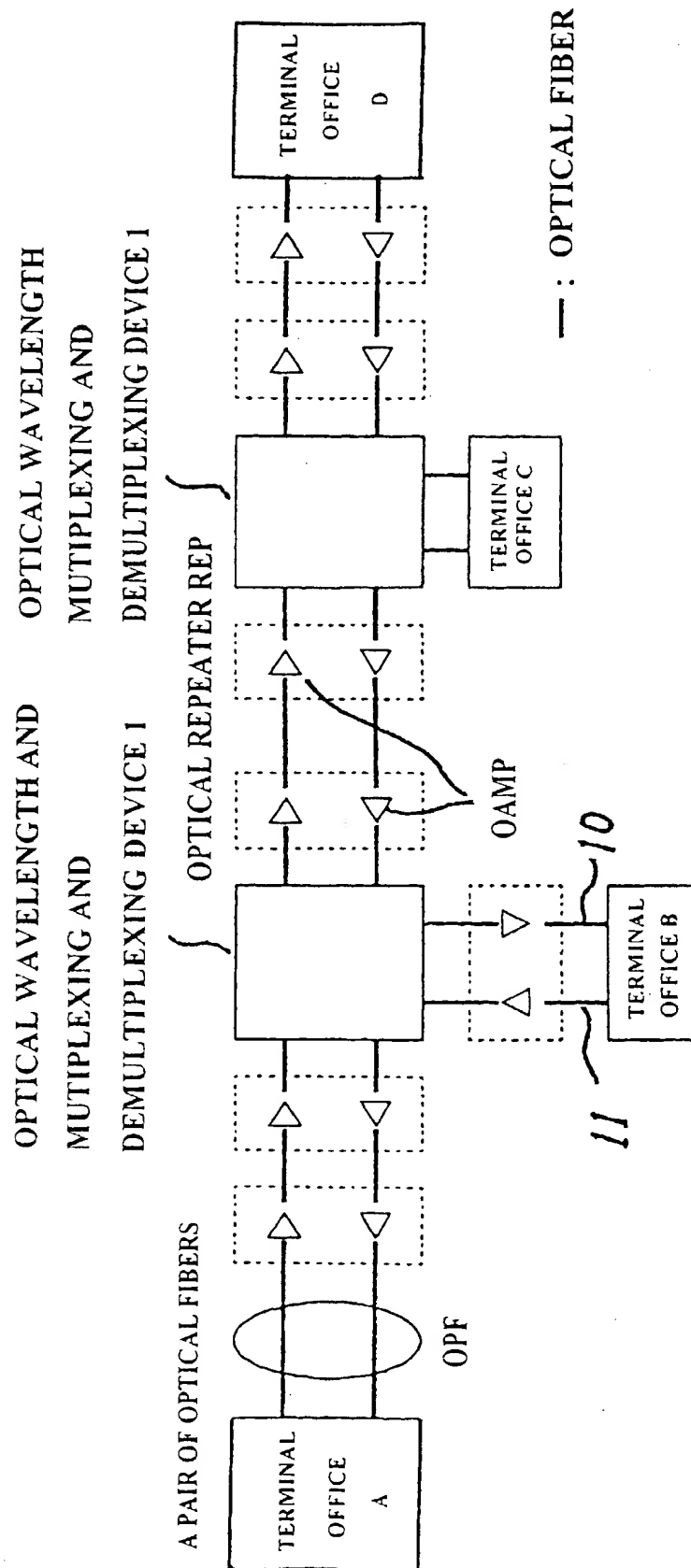


FIG. 9

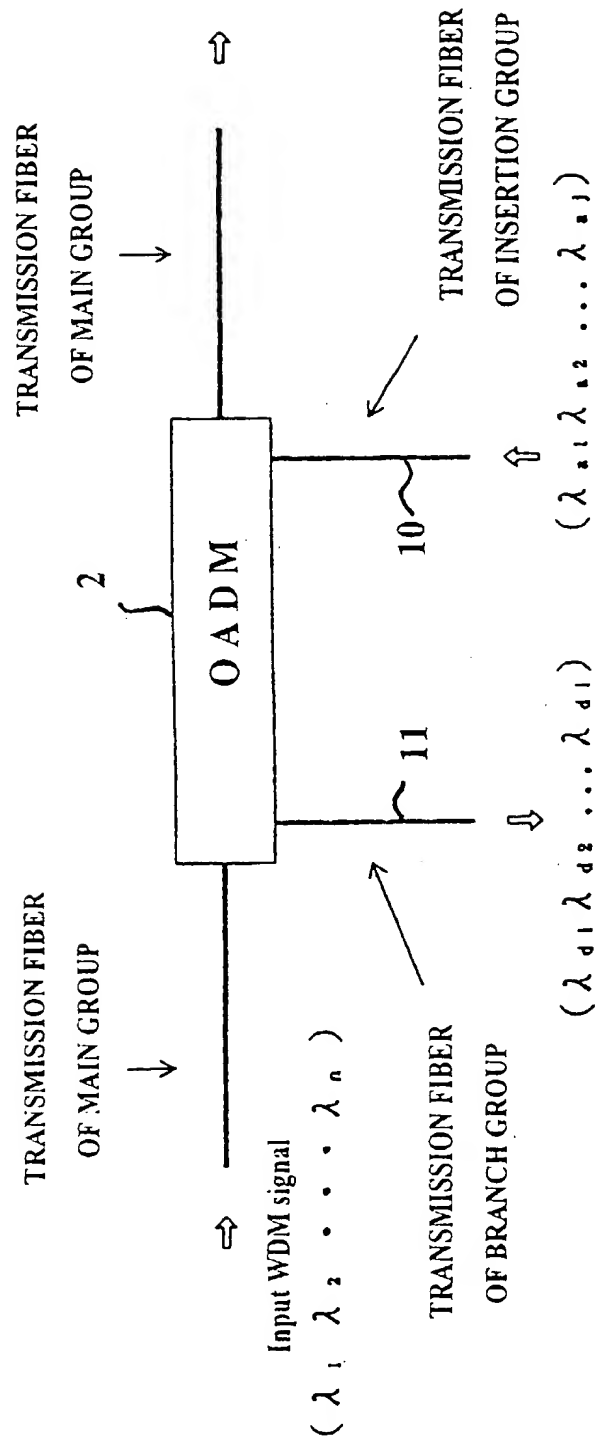


FIG. 10

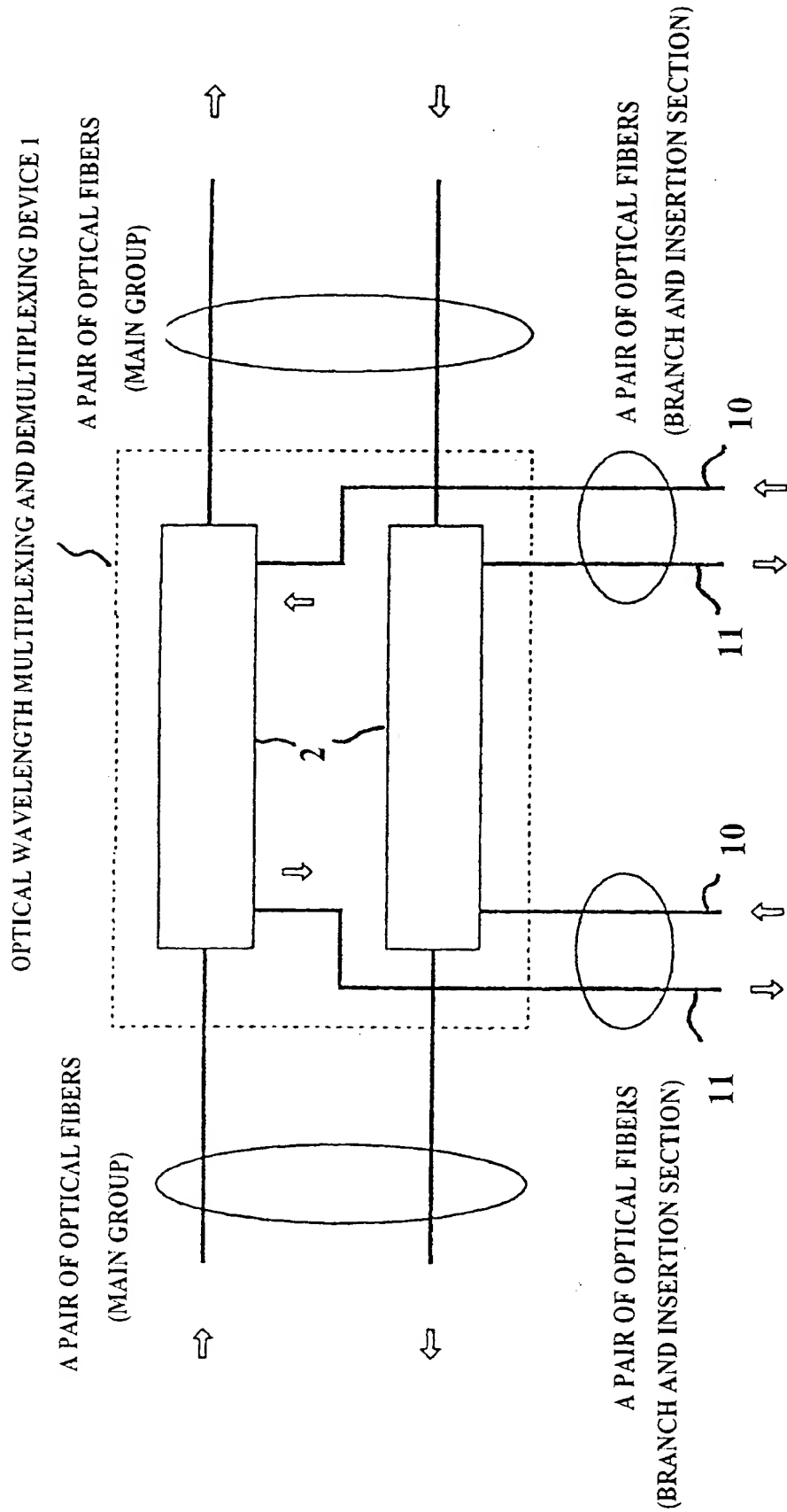


FIG. 11

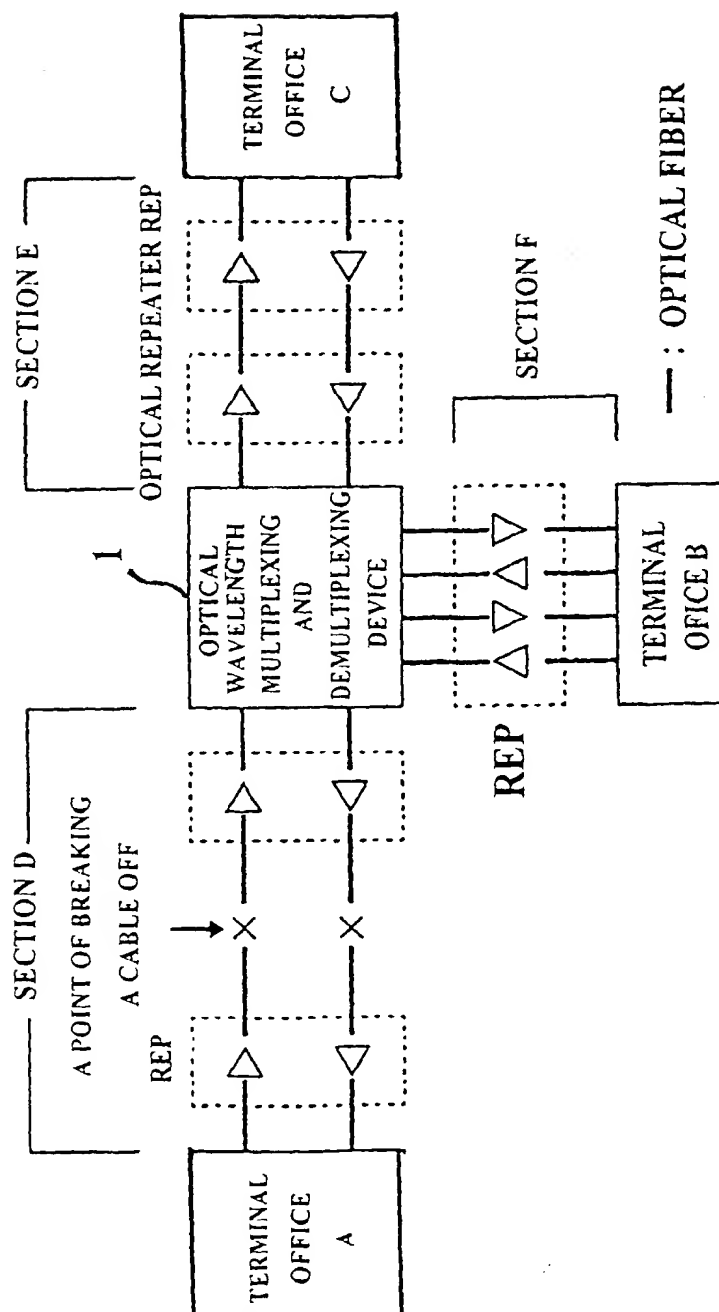
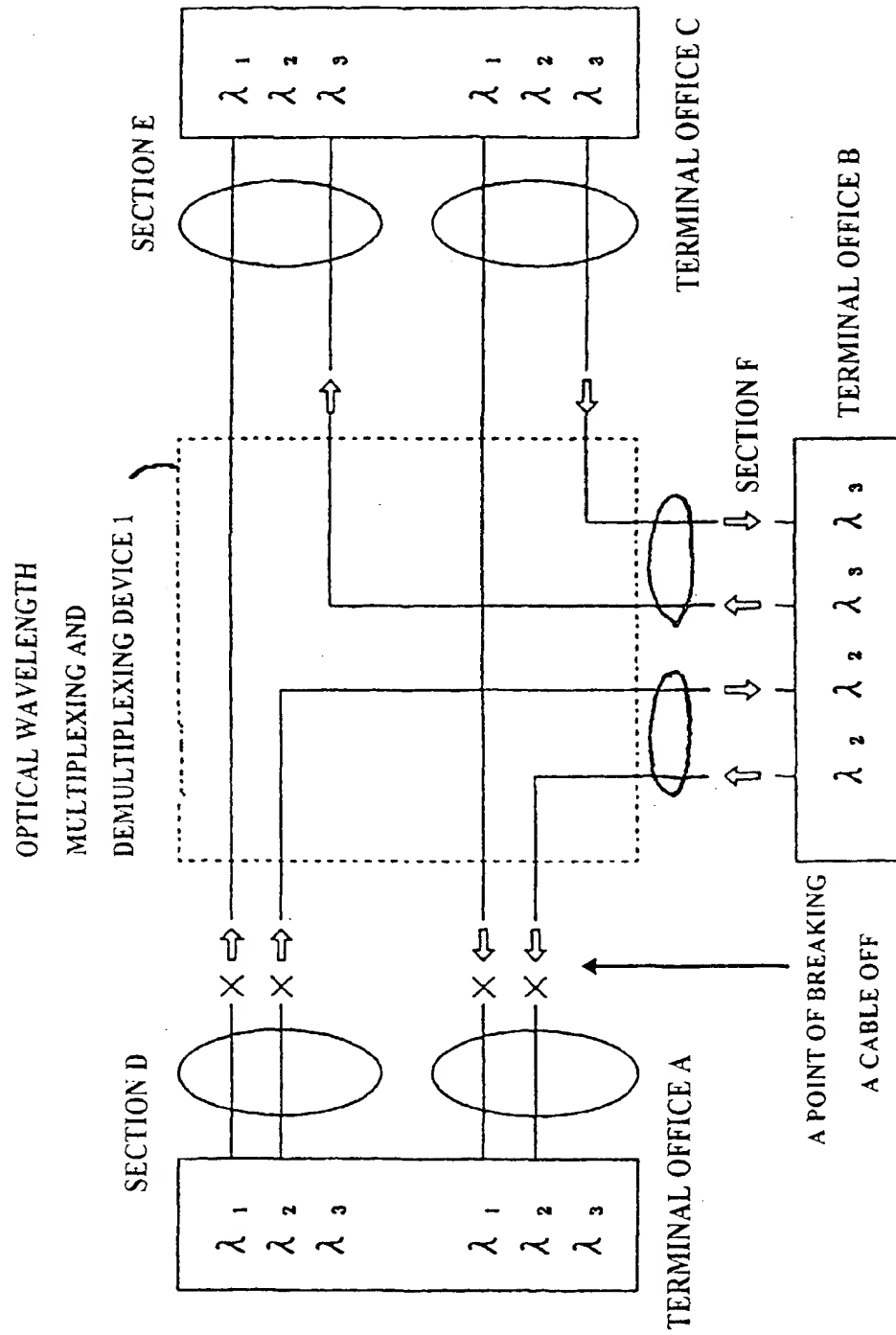


FIG. 12



(19)



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(11)

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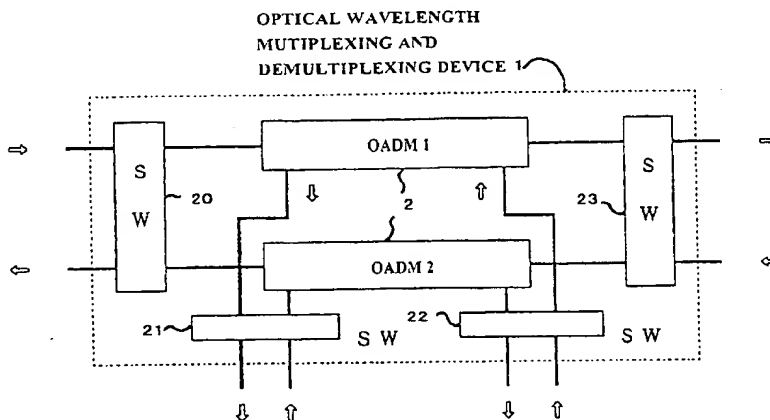
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(54) **An optical wavelength multiplexing and demultiplexing device and an optical transmission system using the same**

(57) An optical wavelength multiplexing and demultiplexing device may transmit an optical signal equivalent to a lost optical signal on a normal section in WDM network. The optical wavelength multiplexing and demultiplexing device includes an optical add-drop multiplexing circuit having a plurality of pairs of input and output ports and a plurality of path switches, each con-

nected to a corresponding pair of the plurality of pairs of input and output ports for breaking off an optical signal inputted to an input port of the corresponding pair, and switching a path of an optical signal output from an output port of the corresponding pair to the input port of the corresponding pair.

FIG. 2



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DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
X A	EP 0 687 085 A (CIT ALCATEL) 13 December 1995 (1995-12-13) * column 1, line 1 - line 10 * * column 4, line 32 - column 6, line 45; figure 2 * * column 13, line 33 - column 15, line 4; figures 6,7 *	1,3,4 7-11	H04J14/02 H04Q11/00 H04B10/213
X	ELREFAIE A F: "MULTIWAVELENGTH SURVIVABLE RING NETWORK ARCHITECTURES" PROCEEDINGS OF THE INTERNATIONAL CONFERENCE ON COMMUNICATIONS (ICC),US,NEW YORK, IEEE, vol. -, 1993 - 23 May 1993 (1993-05-23), pages 1245-1251, XP000371271 ISBN: 0-7803-0950-2 * page 1245, left-hand column, paragraph 1 * * page 1246, left-hand column, paragraph 2 - paragraph 4; figures 3,5A,5B * * page 1247, right-hand column, paragraph 1 - page 1248, left-hand column, paragraph 2; figures 9-12 *	1,2,5,6	
X	JOHANSSON S: "TRANSPORT NETWORK INVOLVING A RECONFIGURABLE WDM NETWORK LAYER - A EUROPEAN DEMONSTRATION" JOURNAL OF LIGHTWAVE TECHNOLOGY,US,IEEE, NEW YORK, vol. 14, no. 6, 1 June 1996 (1996-06-01), pages 1341-1348, XP000598537 ISSN: 0733-8724 * page 1341, left-hand column, paragraph 1 - right-hand column, paragraph 1 * * page 1345, right-hand column, paragraph 2 - page 1347, left-hand column, paragraph 1; figure 14 *	1,2,7,8	
A		5,6	
The present search report has been drawn up for all claims			
Place of search <b>THE HAGUE</b>		Date of completion of the search <b>11 May 2000</b>	Examiner <b>Roldán Andrade, J</b>
<b>CATEGORY OF CITED DOCUMENTS</b> X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document		T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document	

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European Patent  
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# EUROPEAN SEARCH REPORT

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EP 97 11 1539

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
X	EP 0 651 528 A (SIEMENS AG) 3 May 1995 (1995-05-03)	1,7	
Y		8,9	
A	* column 1, line 1 - line 23 *	2,3,10, 11	
	* column 1, line 31 - column 3, line 21 * * column 6, line 4 - column 9, line 47; figures 3,4 *		
Y	--- KITAYAMA K -I: "SUBARRIER MULTIPLEXING BASED SIGNALING AND ACCESS CONTROL IN OPTICAL FDM NETWORKS" IEEE GLOBAL TELECOMMUNICATIONS CONFERENCE (GLOBECOM),US,NEW YORK, IEEE,1995 - 14 November 1995 (1995-11-14), pages 1996-2002, XP000633637 ISBN: 0-7803-2510-9 * page 1996, left-hand column, paragraph 1 * * page 1996, right-hand column, paragraph 3 - page 1998, right-hand column, paragraph 1; figures 3,4 *	8,9	TECHNICAL FIELDS SEARCHED (Int.Cl.6)
A	--- PATENT ABSTRACTS OF JAPAN vol. 008, no. 127 (E-250), 14 June 1984 (1984-06-14) -& JP 59 039131 A (TOKYO SHIBAURA DENKI KK), 3 March 1984 (1984-03-03) * abstract *	1-11	
The present search report has been drawn up for all claims			
Place of search <b>THE HAGUE</b>		Date of completion of the search <b>11 May 2000</b>	Examiner <b>Roldán Andrade, J</b>
<p><b>CATEGORY OF CITED DOCUMENTS</b></p> <p>X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document</p> <p>T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons &amp; : member of the same patent family, corresponding document</p>			

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ON EUROPEAN PATENT APPLICATION NO.**

EP 97 11 1539

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The members are as contained in the European Patent Office EDP file on  
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11-05-2000

Patent document cited in search report		Publication date	Patent family member(s)	Publication date
EP 0687085	A	13-12-1995	FR 2720883 A	08-12-1995
			AU 698474 B	29-10-1998
			AU 2052495 A	14-12-1995
			CA 2151106 A	08-12-1995
			CN 1129503 A	21-08-1996
			WO 9534147 A	14-12-1995
			JP 10508437 T	18-08-1998
			US 5612805 A	18-03-1997
-----				
EP 0651528	A	03-05-1995	NONE	
-----				
JP 59039131	A	03-03-1984	NONE	
-----				

EPO FORM P0459

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82